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(54) METHOD OF INJECTION MOULDING DECORATIVE LAMINATE

(71) We, THE GENERAL TIRE & RUBBER COMPANY, of One General Street, Akron, County of Summit, State of Ohio, United States of America, a corporation organised under the laws of the State of Ohio, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the field of fabricating processes for plastics. More particularly, this invention relates to the fields of injection moulding and vacuum forming of plastics laminates and to the products produced thereby.

The expansion of plastics from plain and simple articles, such as food trays, to more elegant objects, such as ornamental furniture and decorative wall tiles, has placed an increasing burden upon fabricators of these items to develop low-cost techniques that help keep the cost of manufacturing low. Fundamental limitations in conventional fabricating techniques such as the limited degree of draw and low production rate of vacuum forming, the high cost of mould making for injection moulding, and the low production rate of match moulding appear to have curtailed, to some extent, the rate at which plastics are being expanded into new fields.

Certain modifications have been made to conventional injection moulding to increase its versatility and scope of products. For instance, the inherent limitation of product size has been overcome in some instances by assembling preformed pieces in the mould and injection moulding along their mating edges to bond them into a large article. The inherent limitation of moulding thin sections has been overcome in part by prepositioning a thin strip of plastics at the location of the thin section and injection moulding around it (United States Patent 3,424,837).

This invention is another modification of conventional injection moulding wherein a modified injection mould is incorporated in a method that combines the wide range of decorative finishes available in vacuum forming with the high production rate of injection moulding.

According to this invention we provide a method of molding an article in an injection molding device comprising, in combination, cooperating first and second mold members each having a mold surface defining a mold cavity therebetween when closed, means for transferring fluid into and out of said mold cavity through the mold surface of said first mold member, and means in said second mold member allowing the injection of a charge of molten plastics into said cavity, comprising the steps of: placing a film or sheet of vacuum formable material (as herein defined) over the mold surface of said first mold member and against the perimeter defined thereby; vacuum forming said film or sheet of material against said mold surface of said first mold; closing said first and second mold members to envelop said film or sheet of material before or after said vacuum forming and injecting the charge of molten plastics into said cavity against the opposite side of said film or sheet of material to that adjacent the first mold surface to fill said cavity and to form said article.

By "vacuum formable material" we mean film or sheet material which is substantially flat but which, after subjection to vacuum forming against a mold surface, conforms at least in part to the contour of the mold surface and retains that shape after the vacuum forming is complete.

One embodiment of the invention and modifications thereof will now be described with reference to the accompanying drawings, wherein:—

Figure 1 is a cross-sectional view of an injection moulding device showing the first and second mold members in an open position and the step in the moulding process

of placing a sheet of vacuum formable material over the mould surface of the first mould member.

Figure 2 is the same view as in Figure 1 showing the step in the process of vacuum forming the material against the mould surface of the first mould member.

Figure 3 is the same view as in Figures 1 and 2 showing the step in the process of closing the first and second mold members to envelop the sheet of vacuum formed material.

Figure 4 is the same view as in Figures 1 to 3 showing an additional step of opening the mold members and ejecting the molded part therefrom.

Figure 5 is a cross-sectional view of another embodiment of the improved injection molding device and shows the step in the molding process of partially vacuum forming the sheet of vacuum formable material against a highly sculptured mold surface.

Referring particularly to the drawings, wherein like parts are designated by like numbers of reference throughout the five figures, Figure 1 shows an injection molding device that comprises, in combination, cooperating first and second mold members, 3 and 5 respectively, defining a mold cavity 15 (reference Figure 3) when closed. First mold member 3 is shown here as a block of metal or other hard material defined by mold surface 7, mold sides 9 and mold back 11. Mold surface 7 comprises one surface of the article to be molded; the article shown here to be molded is a food tray having a concave upper surface (surface 7) and a convex lower surface (surface 29). As is recognized in the art, mold surface 7 is highly polished to permit easy release of the formed articles and may be covered with a hard wearing metal such as chrome or stainless steel. Defining the outer boundary of mold surface 7 is mold perimeter 13 which is shown here as a flat, beveled surface surrounding mold surface 7 and terminating at the edge of mold sides 9. Mold perimeter 13 is adapted to mate with an oppositely positioned perimeter surface 17 on second mold member 5. In addition to acting as an abutment and mating surface between the first and second mold members 3 and 5, mold perimeter 13 permits air in cavity 15 to escape during the injection of molten plastics later in the process.

First mold member 3 contains air transfer means 19 that is shown here as comprising bore 21 passing through first mold member 3 substantially parallel to the plane of cavity 15 and connected to an air vacuum and pressure source (not shown). A plurality of lesser diameter channels 23 connect mold surface 7 with bore 21 to permit air to transfer to and from mold cavity 15 through mold surface 7. Channels 23 are used to vacuum form a sheet of material against and to separate the formed article from mold surface 7 as will be explained. Means 19 may also comprise other air transfer elements such as interconnected porous metal or ceramic inserts.

Second mold member 5 comprises another block of metal or hard material and is defined by mold sides 25, mold back 27, and mold cavity surface 29. Surface 29 comprises the bottom surface of the food tray to be molded in cavity 15 and is defined by mold perimeter 17 as described earlier. Mold surface 29 is also highly polished and faced with a hard wearing metal or material. Near the center of mold surface 29 is bore 31, passing from surface 29 through to mold back 27, and contains sprue bushing 33 which itself contains sprue adapting surface 35 and sprue 37. In operation, the injection nozzle of a conventional injection molding machine (not shown) is mated with adapting surface 35 and sprue 37 to receive a charge of molten plastics in cavity 15.

Separate from first mold member 3 is a reel 39 of vacuum formable material wherein a sheet 41 of this material is unrolled and pulled up into the opening between open first and second mold members, 3 and 5, and placed over surface 7 of first mold member 3 and against mold perimeter 13 defined thereby. Pressure rollers 43, located about perimeter 13 between the mold members and on the opposite side of sheet 41 from mold member 3, are thereafter moved toward mold member 3 to engage sheet 41 and to pull it taut against mold perimeter 13 — see Figure 2.

In Figure 2, heating means 45 is inserted into the opening between sheet 41, over mold surface 7, and mold surface 29 by drive means 47 and a stream of hot air conveyed therethrough to pass over sheet 41 on mold surface 7 as shown by the dotted line arrows. As the hot air warms vacuum formable sheet 41, air is withdrawn through air transfer means 19 (bore 21 and channels 23) to vacuum form sheet 41 over the contours of mold surface 7. Thereafter heating means 45 is withdrawn from the mold opening and first and second mold members 3 and 5 closed tightly together to envelop the vacuum formed portion of sheet 41 as shown in Figure 3. An injection molding machine nozzle is then positioned against adapting surface 35 of sprue bushing 33 as is known in the art and a charge of molten plastics injected through sprue 37 into cavity 15 and against one side of sheet 41 to form food tray 49. The air in cavity 15 passes through mold vents located along the mating surface of perimeters 13 and 17.

Upon completion of the injection, food tray 49 is cooled below the solidification temperature of the plastics and first and second mold members 3 and 5 are separated. Simultaneous with opening, air transfer means 19

is reversed to apply high pressure air through mold surface 7 via bore 21 and channels 23 to disengage food tray 49 from mold surface 7 and to drop it out of the mold opening into a conveying means (not shown) and to free the mold members for the next molding cycle. The small flap 51 of sheet 41 surrounding food tray 49 that was caught between mold perimeters 13 and 17 is thereafter cut away by hand or machine as is well known in the art. In addition, cutting means (not shown) is engaged to cut sheet 41 from reel 39 to permit free disengagement of food tray 49 and the placing of another sheet of material 41 from reel 39 over the opening of mold surface 7 for the next cycle.

Figure 5 shows a more sophisticated embodiment of first and second mold members 3 and 5 wherein mold surface 7 is comprised of a highly sculptured surface such as is desired in furniture components. Note that channels 23 connect surface 7 with bores 21 and 21a, the latter used where the curvature of the surface requires easier access to air transfer means 19. Prior to mold closure in this embodiment, sheet 41 is only partially vacuum formed over mold surface 7 by operation of air transfer means 19 because the extreme complexity of mold surface 7 does not permit total vacuum forming, i.e. into each and every ridge and groove. Surprisingly, it has been found that a smoothly sculptured surface is obtained by this partial vacuum forming technique. In this embodiment, upon injection of a charge of molten plastic through sprue 37, the high pressure molten plastic will push sheet 41 into full conformity with highly sculptured surface 7 and permit manufacturing of an article having both a textured surface and a high sculptured surface.

Although the preferred embodiment of the process is disclosed as accomplishing the vacuuming forming step prior to closing the mold members, it should easily be recognized that mold members 3 and 5 may be closed after sheet 41 is placed over mold surface 7 and perimeter 13 and before sheet 41 is vacuum formed. Such an interchange of steps in the process is operable and will produce the same results as in the sequence of steps in the preferred embodiment and is fully contemplated in this invention. The reason for having the step of vacuum forming come before the step of closing the mold members is to permit sheet 41 to be vacuum formed uniformly over its area; closing the mold members before vacuum forming would reduce this uniformity to a slight degree.

The injection molding device shown in the figures is only one embodiment of injection molding device that can be used in the method of this invention. The mold cavity may be in virtually any configuration such as a convex surface. All are fully contemplated in this invention. Air transfer means 19 is connected to a conventional vacuum and high pressure source that are known in the art, however, other fluids may be used such as hydraulic oils and the like for certain operations requiring higher heat transfer or better cooling effects than is permitted with air. Air is, however, the preferred means because of cost and equipment considerations.

Mold surfaces 7 and 29 may have a textured finish other than the smooth surface contemplated as the preferred embodiment of this invention; however, such textured surfaces involve undue expense and are generally not needed because the textured finish for the molded article may be obtained completely from sheet 41.

First and second mold members 3 and 5 may be used in a conventional injection molding machine without undue modification of the equipment. There is normally space around the mold opening for positioning reel 39, pressure rolls 43, and heating means 45 so that these do not require undue modifications of the equipment.

The step of placing sheet 41 over the surface of first mold member 3 and against perimeter 13 defined thereby may be accomplished merely by lifting the sheet from reel 39 and drapping it across the mold opening or may be accomplished automatically by machine. The primary requirement is that sheet 41 be placed over the surface of first mold member 3, unwrinkled, and against the perimeter defined thereby.

Sheet 41 may be any of a wide range of vacuum formable materials in film or sheet form. Film and sheet are terms applied to different thicknesses of layered goods; films are thinner than 0.010 inches (10 mils) and sheets are 10 mils and thicker. Both films and sheets are includable as sheet 41. The vacuum formable materials comprise films and sheets of vinyl polymers and copolymers, polymeric foams such as vinyl and polyurethane, and laminates of these such as fabric-supported vinyl and fabric-faced foam.

Films and sheets of vinyl polymers are made by a number of well-known processes. For instance, vinyl powder, such as polyvinyl chloride, is admixed to a liquid plasticizer such as dioctyl phthalate, and cast in a film or sheet. Heat is applied to cause the powder to absorb the plasticizer and then further heat is applied to fuse the swollen particles into a continuous flexible film. This film may be laminated to a sheet of polymeric foam or fabric and these laminates are also usable as sheet 41. A gassifying agent, such as an azocarbamide, may be mixed with the powder and plasticizer and caused to gassify during fusion of the swollen vinyl powder to form a cellular sheet or film that is also usable as sheet 41. Sheets of flexible polyurethane foam may be made by reacting a polyester or

polyether polyol with an organic isocyanate, and optionally water, blowing agents, catalysts, and surface active agents, casting the mixture into a sheet, and applying heat thereto. These and other thermoplastics and thermosetting plastics sheets and films are fully operable and contemplated herein.

The primary reason for using sheet 41 is to place a decorative finish on the molded part without going to the expense of cutting a negative of the decorative finish into the mold surface. The use of sheet 41 also permits changing the decorative finish without changing molds. The decorative finishes that may be placed on sheet 41 include the finishes normally placed on plastics film and sheeting such as embossed patterns, silk screened patterns, printed patterns, photographed patterns, hand painted patterns, etc. Specific examples of these include embossed and painted simulated wood grain finish, embossed and painted simulated leather finish, painted foam finish, silk screened or printed finishes, patent leather finish, and suede finish.

As is described earlier, sheet 41 is vacuum formed onto mold surface 7 prior to injecting a charge of molten plastics against it to form the article. Because film and sheeting exists in various strengths and stiffnesses, it may become necessary to augment the vacuum forming step with well-known practices that are fully within the ability of one skilled in the molding art. For instance, with stiff or high modulus film and sheeting, it is likely that softening of sheet 41 will be needed to permit vacuum forming without tearing or loss of embossed design. Conversely, with flexible or low modulus film and sheeting, such a softening step will not be needed, in fact, it may not be permitted in order to maintain the embossed design. When softening is desired, heating means 45 is utilized to direct hot air or other fluid over sheet 41 as shown in Figure 2.

Heating means 41 may comprise other types of heating units than is shown in Figure 2. For instance, a bank of CAL-ROD* heaters or high-intensity lights may be used. In addition, a radioactive source may be used. All these are fully contemplated herein.

The plastics injected into cavity 15 by the injection molding machine comprises all types of thermoplastic injection moldable plastics such as polystyrene, styrene-acrylonitrile (SAN), acrylonitrile-butadiene-styrene (ABS), polyvinyl chloride (PVC), polyvinyl acrylate, cellulose acetate, polyethylene, polyacrylics, nylon, polycarbonates, and polypropylene. Others include thermosetting plastics such as urea-formaldehyde resins.

An important aspect in this process is to obtain a good bond between the injection molded plastics and the sheeting. In many instances a good bond is obtained without special treatment such as in molding styrene-acrylonitrile plastic against a decorative vinyl film. In other cases the degree of bonding is less than that desired and is enhanced by placing a coating of adhesive on the surface of sheet 41 that faces cavity 15. As a specific example, to increase the degree of bonding between a vinyl film and an injection molded acrylonitrile-butadiene-styrene (ABS) resin, a coating of ATLAS* SY71.11 adhesive, made by Atlas Coatings Corporation, Long Island, New York, is applied to the vinyl film and dried prior to placing the film in the mold. Examples of other adhesives include acrylics, alkyds, bitumens, casein, cellulose acetate, cellulose caprate, cellulose nitrate, cyanoacrylate epoxy-polyamide, phenolic-polyamide, phenolic-vinyl, polyamide, polyisobutylene, polystyrene, polyvinyl acetal, polyvinyl acetate, rosin, epoxides, furanes, melamine-formaldehyde, oleoresins, phenolformaldehyde, phenolic-epoxy, phenolic-neoprene, phenolic-nitrile, polyesters, polyurethanes, resorcinol-formaldehyde, urea-formaldehyde, polychloroprene, and acrylonitrile-butadiene. These may be applied in a wide variety of processes such as spraying, roll-coating and brushing.

Another important aspect of this process is encountered when molding against a highly sculptured surface as shown in Figure 5. As is known in the vacuum forming art, it is essential to draw the film into full conformity with the surface to obtain a high degree of fidelity or reproduction of the surface. As incorporated in this process, it was initially noted that full vacuum forming against a highly sculptured surface was virtually impossible because of the extreme detail of the surface and the inherent limitation in the number of air transfer channels 23 that could be drilled into surface 7 without damaging the sculptured effect. It was also thought that high pressure against vacuum formed fibers would smooth out the embossed design. It was therefore surprising to find that if sheet 41 were only partially vacuum formed against surface 7, the charge of molten plastics under high pressure from the injection molding machine would complete the surface forming without loss of surface definition. It was thus found that this aspect of the invention permited the inherent limitation of a limited degree of draw and a limited degree of surface sculpturing, occasioned in conventional vacuum forming, to be overcome and permitted manufacture of decorative laminates having highly sculptured surfaces. One must be particularly careful, however, to apply only the minimum

* "Cal-Rod" is a Registered Trade Mark.

* "Atlas" is a Registered Trade Mark.

amount of heat necessary to soften sheet 41 to permit partial vacuum forming against the highly sculptured surface and maintain only the minimum temperature of the molten plastics charge to insure adequate melt flow and mold cavity fill. Higher temperatures and/or over softening of sheet 41 may result in loss of embossing during injection molding. These skills are fully within the ambit of one skilled in the molding art.

A still further aspect of this process is that at least some degree of vacuum forming must be accomplished prior to injecting the charge of molten plastics into cavity 15. Tests have shown that if sheet 41 is not at least partially formed upon mould member closure the sheet comes in contact with sprue 37, then, upon injection, the molten plastic burns through sheet 41 in front of sprue 37 and accumulates plastics on both sides of the sheet to bury it in the article and render it useless.

We have found that the products produced by the process described above may obtain the benefits of the wide variety of surface patterns and textures attributable to the preformed sheet material, a wide range of surface features from almost planar to highly sculptured attributable to the capability of injection moulding techniques, and the low cost of fabrication stemming from the injection moulding system. Furthermore, injection moulded articles having both rigid and soft surfaces, the latter stemming from vacuum formable sheet material of the polymeric foam variety, have been found to be available from this invention.

Thus it will be seen from the foregoing description that we have found that this invention can result in a method of fabricating improved decorative laminar structures both plain and elegant. The inherent limited degree of draw and low production rate of vacuum forming was found to be overcome, as well as the high cost of textured mould making for injection moulding and a new, low-cost fabricating technique may thus be made available to the plastics industry.

WHAT WE CLAIM IS:—

1. A method of molding an article in an injection molding device comprising, in combination, cooperating first and second mold members each having a mold surface defining a mold cavity therebetween when closed, means for transferring fluid into and out of said mold cavity through the mold surface of said first mold member, and means in said second mold member allowing the injection of a charge of molten plastics into said mould cavity, comprising the steps of:

a) placing a film or sheet of vacuum formable material (as herein defined) over the mold surface of said first mold member and against the perimeter defined thereby;
b) Vacuum forming said film or sheet of material against said mold surface of said first mold;
c) closing said first and second mold members to envelop said film or sheet of material before or after said vacuum forming; and,
d) injecting the charge of molten plastics into said cavity against the opposite side of said film or sheet of material to that adjacent the first mold surface to fill said cavity and to form said article.

2. The method of Claim 1 including the step of softening said film or sheet of vacuum formable material prior to vacuum forming it against said mold surface.

3. The method of Claim 1 or 2 wherein said step of vacuum forming said sheet of material against said mold surface of said first mold member is carried to the extent that said film or sheet is only partially vacuum formed.

4. The method of Claim 1 or 2 wherein said step of vacuum forming said sheet of material against said mould surface of said first mould member is carried to the extent that said sheet is fully vacuum formed.

5. The method of any one of the preceding Claims including the subsequent step of opening said first and second mould members and transferring air to said mould cavity, through said mould surface of said first mould member, to separate said article from said mould surface and eject said article from said injection moulding device.

6. The method of any one of the preceding Claims wherein said sheet of vacuum formable material contains a coating of adhesive on the surface facing said mould cavity.

7. The method of any one of the preceding Claims wherein said vacuum formable material comprises a thermoplastic.

8. The method of Claim 7 wherein said sheet of vacuum formable material comprises a foamed thermoplastic.

9. The method of any one of Claims 1 to 6 wherein said vacuum formable material comprises a polymeric foam.

10. The method of Claim 9 wherein said vacuum formable material comprises a polyurethane foam.

11. The method of Claim 7 wherein said vacuum formable material comprises a fabric-backed thermoplastic.

12. A method of moulding an article in an injection moulding device according to Claim 1 substantially as described herein.

13. An article produced by the method of any one of Claims 1 to 12.

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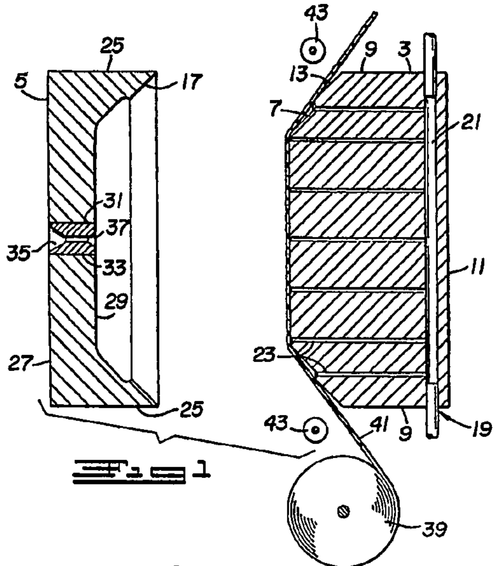

Fig 1

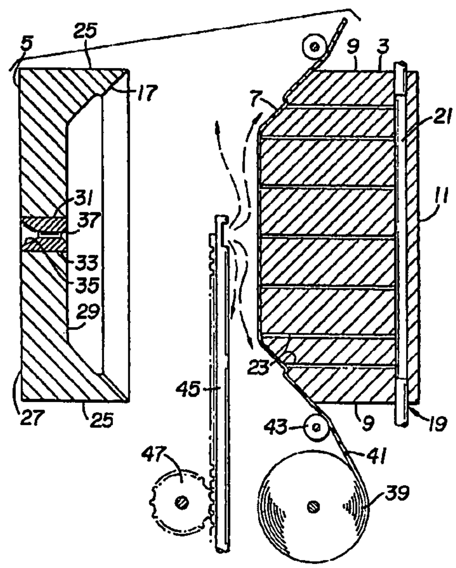

Fig 2

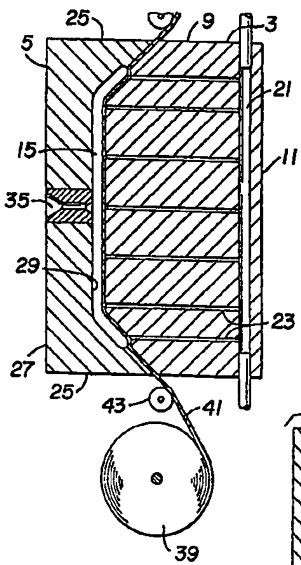

Fig 3

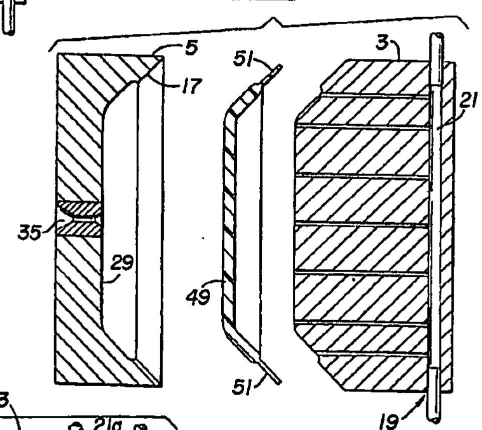

Fig 4

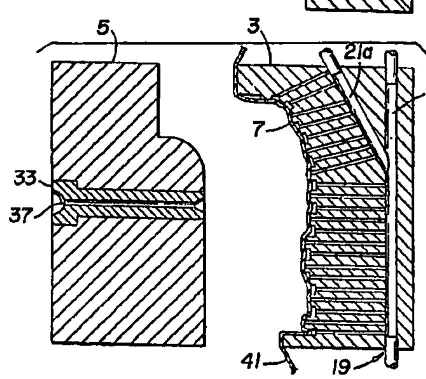

Fig 5